OVERSIGHT

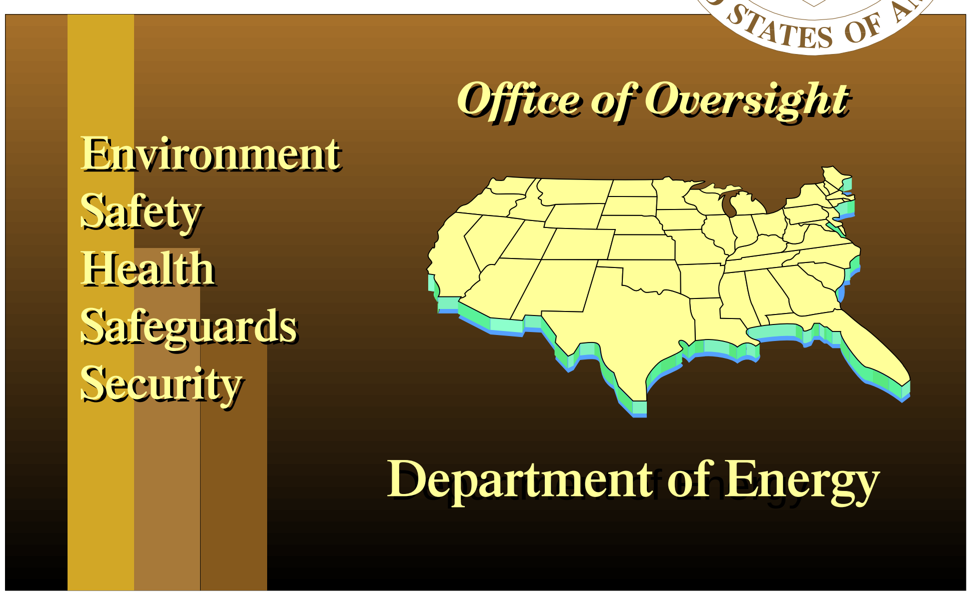
Interim Report
on the

Office of Environment, Safety and Health Oversight of Groundwater Tritium Plume Recovery Activities

at the

Brookhaven National Laboratory

February 1997



Office of Environment, Safety and Health

INTERIM REPORT ON THE OFFICE OF ENVIRONMENT, SAFETY AND HEALTH OVERSIGHT OF GROUNDWATER TRITIUM PLUME RECOVERY ACTIVITIES AT THE BROOKHAVEN NATIONAL LABORATORY

February 1997

Office of Oversight
Environment, Safety and Health
U.S. Department of Energy
Washington, DC 20585

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EXECUTIVE SUMMARY

EVALUATION: Office of Oversight evaluation of Department of Energy and contractor activities related to recovery from tritium contamination

SITE: Brookhaven National Laboratory

DATES: January 27 to February 14, 1997

BACKGROUND

In January 1997, groundwater samples taken from recently-installed monitoring wells south of Brookhaven National Laboratory's (BNL) High Flux Beam Reactor (HFBR) indicated tritium levels in excess of Environmental Protection Agency (EPA) limits for drinking water. The HFBR remains shut down pending resolution of the tritium plume.

On January 27, 1997, the Assistant Secretary for Environment, Safety and Health (EH) dispatched a team to perform an independent oversight evaluation of the BNL and Department of Energy (DOE) activities related to recovery from tritium contamination. This review is the first installment of comprehensive oversight of environment, safety, and health management at BNL.

HISTORY OF GROUNDWATER MONITORING AT THE HFBR

In 1992, BNL determined that three to five wells at the HFBR would be beneficial but that HFBR monitoring was a low priority, and no actions were taken. The issue surfaced again in 1994 when the Suffolk County Department of Health Services formally informed BNL that the fuel canal (used to store highly radioactive spent fuel from the HFBR) did not comply with county code requirements for hazardous material storage tanks; they did not have secondary containment or low level leak detection. A commitment was made to Suffolk County to install two monitoring wells down gradient of HFBR in 1995, but funding reductions resulted in delay until 1996.

The reasons for the delays in installing groundwater monitoring wells south of HFBR are complex. The historical approach has been to focus groundwater monitoring on known contamination facilities and potential contamination sources near the site boundary. This is a credible approach in the initial stages of site cleanup and environmental restoration, and the delays in monitoring groundwater were made within the context of other sitewide environmental concerns that were formally prioritized. Within the past five years, there have been significant actions taken to improve the environmental protection program at BNL.

From an individual facility standpoint, HFBR was apparently not considered a high probability to impact groundwater quality. However, it appears as though BNL did not rigorously analyze the potential for releases from the HFBR and was somewhat overconfident in the control of effluents from the HFBR. For example, the 33-year-old concrete fuel canal was built in accordance with design requirements at the time, but does not have provisions for secondary containment as required by current standards (engineering design calculations indicated that the permeability of the concrete in the fuel canal could result in leakage of 3 to 8 gallons per day from the canal). In addition, after responding to the known sources of contamination, BNL did not implement a sitewide hydrogeological approach to the prioritization of monitoring.

In retrospect, it is not possible to say whether consideration of these factors would have resulted in different decisions about the priority of HFBR groundwater monitoring in light of BNL's focus on known or suspected contamination sites and the site boundary. However, it appears that many of the decisions about HFBR groundwater monitoring were made within lower levels of the BNL organization, that communications among various DOE and BNL organizations (e.g., between the BNL Reactor Division and the Safety and Environmental Protection Division) were not as effective as they should be, and that senior managers were not sufficiently involved in the decision processes and may not have had all of the information necessary to make good decisions about the priority of HFBR monitoring. More timely action by BNL to monitor groundwater south of HFBR and to better monitor and control effluents could have identified the tritium plume sooner and helped mitigate groundwater contamination.

CURRENT BNL INITIATIVES

The tritium plume appears to be relatively shallow and about 1.3 miles from the southern site boundary. It does not pose an immediate threat to drinking water, workers, or the public. At the same time, Long Island is a densely populated area, and BNL site, private, and public water supplies are from a sole source aquifer.

BNL's recovery efforts have been focused primarily on determining the source of the tritium and on obtaining additional samples to develop a better understanding of the extent and location of contamination. In general, the sample analysis for tritium is being properly performed by the BNL analytical laboratory. The independent analyses of duplicate samples being performed by the EPA and Suffolk County/New York State have produced results that are very similar to the BNL results, thus indicating that the BNL sample and analysis methods are reliable. Based on its analysis of groundwater samples and historical reactor operations data, BNL is now focusing on two potential sources (i.e., the fuel storage canal and a 1995 primary coolant pump seal failure and discharge of primary coolant to the reactor building).

In the early stages of the response to the detected contamination, there were some initial problems in developing a coordinated approach to resolving the issue. For example, the responsibilities for managing the effort were unclear, and ideas being generated by individuals were not well communicated, evaluated, and translated to concrete actions where appropriate. In late January, BNL restructured its recovery team and developed a plan that more clearly defines necessary near-term and longer-term actions, defines specific roles and responsibilities, and better integrates sitewide resources and organizations into the recovery effort. Currently, BNL and DOE, including Headquarters, the Chicago Operations Office (CH), and CH's local Brookhaven Group (BHG), are combining resources and working together toward a timely and effective resolution.

The results of this interim evaluation indicate that the approach to the recovery of the HFBR tritium plume, particularly since BNL restructured its management approach to resolution of this issue, is responsive to the problem as well as to public and stakeholder interests and concerns.

OPPORTUNITIES FOR IMPROVEMENT

Because of the pace of developments on these issues, some of these opportunities may already be under consideration by BNL.

Expedite planning related to tritium plume source resolution. The determination and confirmation of which of the two potential sources is the actual leak may take considerable time. Because of the lead time necessary to procure equipment and services, perform safety analyses, obtain regulator approvals and permits, and arrange project funding, planning actions to resolve both potential sources should not be delayed while BNL attempts to determine the actual source.

Expedite planning for mitigation and remediation of the tritium plume. Although the HFBR tritium plume does not represent an immediate public or worker health concern, public anxiety resulting from the increasing reported levels and the perceived potential impact on the sole-source aquifer is growing quickly. Efforts to mitigate and remediate this plume, therefore, should be expedited and should not be delayed until source identification is completed.

Ensure a structured BNL and DOE management review and approval process. The pressures and aggressive schedules involved with the tritium plume recovery, as well as the many options available, create the potential for decisions that may carry risks, that may not be the most effective options available, or that might not be supportive of BNL, DOE, or stakeholder interests. It is critical that thorough and effective hazard analysis be part of the decision process, and that senior managers (representing CH, BHG, BNL, and the DOE Offices of Energy Research, Environmental Management, and Nuclear Energy) are provided with the information needed to make good decisions.

Apply lessons learned to improve BNL groundwater monitoring and remediation programs. To ensure effective prioritization, DOE and BNL should approach the prioritization and location of groundwater monitoring wells from a sitewide hydrogeologic standpoint. DOE and BNL should improve the funding methodologies for the sitewide groundwater monitoring program and assure that budget reductions properly consider environmental priorities.

ACRONYMS AND INITIALISMS

ADS	Activity Data Sheet
ALARA	As Low As Reasonably Achievable
ASL	BNL Analytical Services Laboratory
AUI	Associated Universities, Inc.
BNL	Brookhaven National Laboratory
BHG	Chicago Operations Office Brookhaven Group
CERCLA	Comprehensive Environmental Response Compensation Liability Act
CH	DOE Chicago Operations Office
DOE	U.S. Department of Energy
EH	DOE Office of Environment, Safety and Health
EM	DOE Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ER	DOE Office of Energy Research
ES&H	Environment, Safety, and Health
HFBR	High Flux Beam Reactor
NE	DOE Office of Nuclear Energy
NPL	National Priority List
NRC	U.S. Nuclear Regulatory Commission
ORPS	Occurrence Reporting and Processing System
PE	BNL Plant Engineering Division
SCDHS	Suffolk County Department of Health Services
S&EP	BNL Safety and Environmental Protection Division
VOC	Volatile Organic Compound

INTERIM REPORT ON THE OFFICE OF ENVIRONMENT, SAFETY AND HEALTH OVERSIGHT OF GROUNDWATER TRITIUM PLUME RECOVERY ACTIVITIES AT THE BROOKHAVEN NATIONAL LABORATORY

1.0 INTRODUCTION

➪ The review of tritium contamination at BNL was conducted in two phases.

This interim report presents the U.S. Department of Energy (DOE) Office of Environment, Safety and Health (EH) Office of Oversight evaluation of the status of tritium contamination of the groundwater at Brookhaven National Laboratory (BNL). The review of tritium contamination is the culmination of the first of a two-phased Oversight evaluation of environment, safety, and health management at BNL.

The first phase is intended to provide DOE management and other interested parties with a timely review of BNL and DOE effectiveness in dealing with the tritium contamination. The second phase provides a more systematic and comprehensive assessment of the overall status of safety management programs at BNL. (Note: As used in this report, the term "safety management" refers to all aspects of environment, safety, and health programs.) Safety management evaluations are performed at major DOE sites to determine how effectively DOE and contractor line management have implemented environment, safety, and health programs. The second phase of the safety management evaluation is expected to be completed at the end of April 1997. Following the completion of the safety management evaluation, the Office of Oversight will continue to monitor progress and actions at BNL and will conduct additional onsite reviews as needed to verify that appropriate actions were effectively implemented.

Concerns associated with tritium contamination of groundwater at BNL prompted EH to accelerate the original schedule for the Office of Oversight integrated safety management evaluation at BNL. In December 1996, specifically, significantly-elevated concentrations of tritium were detected in monitoring wells installed south of BNL's High Flux Beam Reactor (HFBR). Levels exceeding drinking water standards were identified in January 1997.

➪ Proposed mitigative and corrective actions were evaluated.

In this first phase, the EH Oversight Groundwater Review Team evaluated the adequacy of the ongoing BNL sampling and analysis program and the benefits and potential drawbacks of proposed mitigative and corrective actions. The Review Team was led by two experienced DOE managers and included technical experts in the areas of nuclear engineering, nuclear safety, waste management, environmental compliance, waste water treatment, hydrogeology, health physics, and tritium.

Figure 1 provides some background information on BNL, the HFBR, and tritium. Figure 2 shows the DOE and contractor organizations responsible for managing activities at BNL and the role of EH and the Office of Oversight in performing independent assessment. Photographs of the site and the HFBR are included at the end of this report.

Brookhaven National Laboratory

BNL was established in 1947 as a laboratory to advance scientific research. The Laboratory carries out basic and applied research in high-energy nuclear and solid state physics; fundamental material and structural properties and interactions of matter; nuclear medicine; biomedical and environmental sciences; and selected energy technologies.

The laboratory has a full-time staff of approximately 3,500 employees, including 1,250 scientists and engineers. In addition, the site supports an annual resident population of 1,500 individuals, predominantly researchers, scientists, visiting professors, and students involved in short-term experiments.

High Flux Beam Reactor

HFBR is a heavy water moderated and cooled research reactor used principally for basic experimental research requiring external neutron beams. The reactor began operation in October 1965 and has been in service since that time. The reactor produces neutrons to support research in scattering experiments in nuclear and condensed matter physics, and structural biology and chemistry. It has facilities for isotope production and material irradiation.

Typically, the reactor is operated for approximately 30 days, shut down for refueling for 7 days, and then restarted. Since the reactor is heavy water moderated and cooled, tritium is produced by neutron absorption in the coolant and is a byproduct of operation. Tritium concentrations in the reactor primary coolant are maintained in the range of 1.5 to 2.7 Curies per liter. Most of the tritium at BNL was produced in the HFBR.

Tritium and Its Health Effects

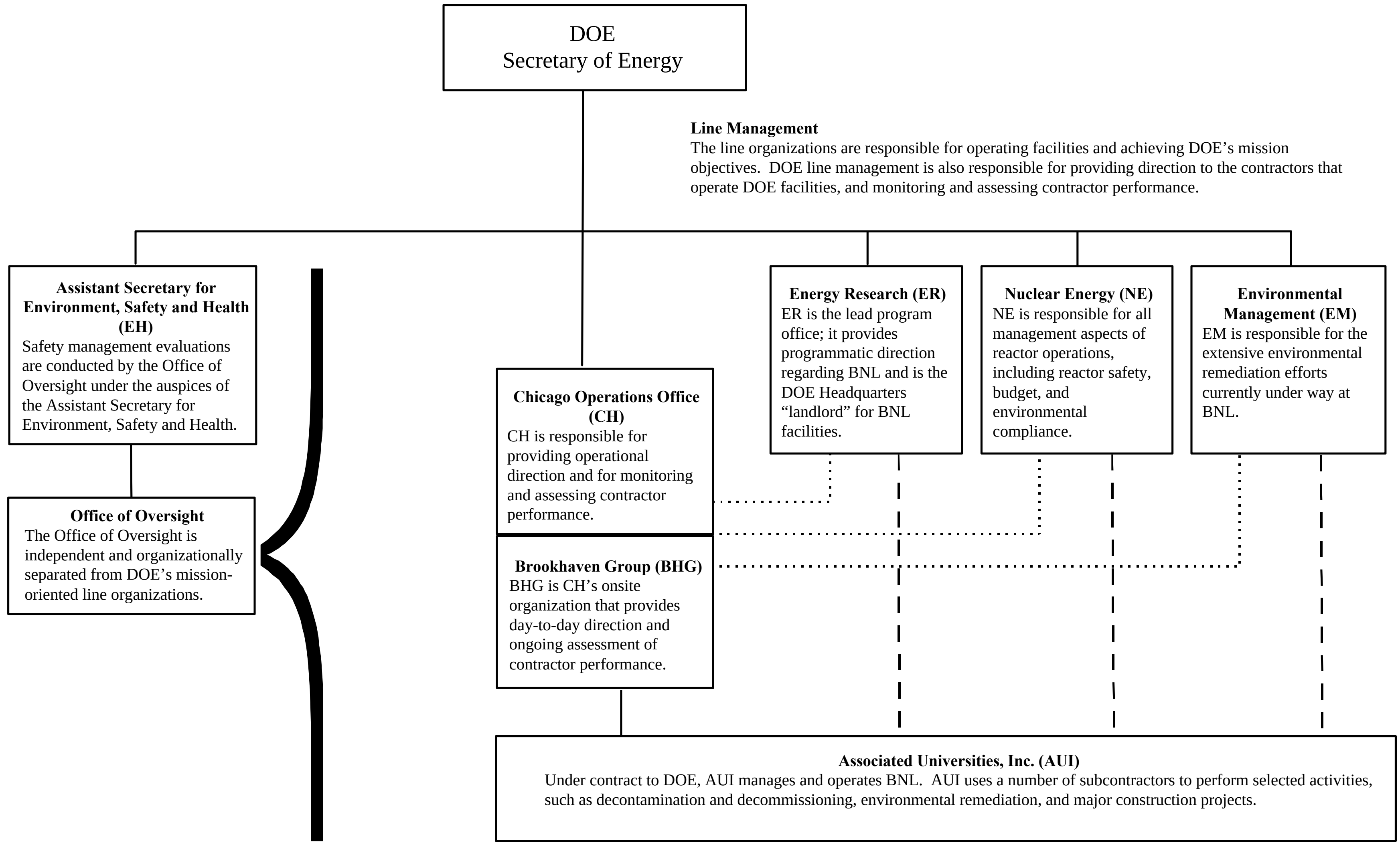
Tritium is the rarest isotope of hydrogen (the most common form of hydrogen has one proton; deuterium, a rare stable isotope of hydrogen has one proton and one neutron; and tritium, which is present in nature in trace amounts, has one proton and two neutrons). Tritium is chemically identical to hydrogen, combining with oxygen to form water. Trace amounts of tritium are everywhere because water is everywhere.

Tritium is unstable. It has a radioactive half life of 12.3 years and a biological half life of 14 days). It emits low energy beta particles when it decays; beta particles do not readily penetrate materials. Tritium is a health concern (in large quantities) if ingested or absorbed in the body (tritium can be absorbed through the skin in the same way as normal hydrogen/water).

According to a 1996 New York State Department of Health Services report, normal surface water and shallow groundwater in New York contains about 100 to 300 pCi/L of tritium. This “background” tritium is generated by cosmic radiation in the upper atmosphere, and fallout from atmospheric nuclear tests in the 1950s and 1960s.

The EPA dose limit for drinking water is 4 millirem per year, with a resultant standard for the concentration of tritium in drinking water of 20,000 pCi/L. For comparison, the NRC and DOE both have a general public radiation limit of 100 millirem per year, and the average person in the U.S. receives about 300 millirem per year from natural (e.g., radon) and common manmade (e.g., medical x-rays) radiation sources.

Figure 1. Background Information



As an independent organization, the Office of Oversight performs "top to bottom" reviews of the effectiveness of management (from the DOE program office, to the DOE operations office, to the DOE area offices, to the management and operating contractors, to subcontractors, and ultimately to the workers at selected facilities) in achieving environment, safety, and health objectives.

Figure 2. Organizations With Responsibilities at Brookhaven National Laboratory

Scope

➩ The focus is exclusively on the tritium contamination at the High Flux Beam Reactor.

Although other sources of tritium are evident and have contributed to groundwater contamination in the past, the focus of this evaluation is exclusively on the recently discovered contamination plume in the immediate vicinity of the HFBR. This report documents the results of this interim independent oversight activity and the status of plume recovery through Friday, February 7, 1997.

➩ BNL's initial plans will continue to evolve.

It is important to recognize that BNL's characterization of the sources and extent of tritium contamination in groundwater south of the HFBR is in the initial stages. Plans to better identify and isolate the sources, characterize the contamination, and implement mitigative and corrective actions are continuing to evolve as information is obtained from an ongoing sampling and analysis program. Consequently, this evaluation represents the status at this point in time. The objective of this interim report is to provide DOE management and other interested parties with an independent assessment of the current status of BNL actions to address the tritium contamination issue, and the effectiveness of actions that haven been taken to date (data collection activities for the first phase of this review nominally ended on February 7, 1997).

➩ The Review Team activities included meetings with Environmental Protection Agency and county officials.

The EH Oversight Groundwater Review Team interviewed a wide range of DOE and BNL staff, reviewed sampling procedures, observed samples, inspected well locations, toured facilities, reviewed numerous documents. conducted numerous observations of activities associated with plume recovery, attended recovery planning meetings, and conducted interviews and facility walkdowns. On several occasions, the team met with Region II Environmental Protection Agency (EPA) and the Suffolk County Department of Health Services on the status of tritium plume recovery efforts and EPA duplicate sampling analysis results.

Report Organization

This report is organized to provide a perspective on DOE and BNL effectiveness in two distinct periods of time. Section 2 provides an assessment of DOE and BNL actions up until tritium contamination was discovered at the HFBR, more specifically on the events that led to the installation of wells to monitor the groundwater at the HFBR. Section 3 discusses DOE and BNL actions after tritium contamination was discovered, focusing on three key areas associated with plume recovery:

- **Tritium Source Identification and Resolution:** The possible release pathways by which significant quantities of tritium could be reaching the groundwater near the HFBR, and methods under consideration for eliminating source(s) of tritium contamination.

- **Groundwater Investigation and Plume Recovery:** The methods for characterizing the groundwater and the size of the plume, and methods under consideration for mitigating the contamination.

- **Groundwater Sampling and Analysis Techniques:** The methods for sampling and analyzing groundwater, including quality assurance, to ensure that the sampling results are an accurate representation of the actual level of contamination.

Section 4 identifies opportunities for improvement that should be considered by DOE and contractor management.

2.0 HIGH FLUX BEAM REACTOR GROUNDWATER MONITORING

Because of the high concentrations of tritium, the focus of this review is exclusively on the tritium contamination in the groundwater in the area adjacent to the HFBR, and this section focuses on the actions taken at BNL that led to the installation of wells and the subsequent detection of tritium contamination. However, decisions about the priority of HFBR monitoring were made in the context of BNL's environmental restoration and environmental groundwater modeling program. Figure 3 provides background information on these programs.

> ➪ The need for groundwater monitoring was recognized in 1992 but assigned low priority.

Figure 4 provides a timeline of some of the key events relating to the decisions to install groundwater monitoring wells at the HFBR. The chronology of events indicates that the potential need for groundwater monitoring south of HFBR was first recognized by BNL in 1992. A Nuclear Regulatory Commission (NRC) Information Notice (92-11) on soil and water contamination at fuel cycle facilities prompted an evaluation by BNL of the need for monitoring wells south of HFBR and in the direction of groundwater flow. BNL determined that three to five wells south of the HFBR would be useful, but a low priority, unless operations data suggested otherwise.

> ➪ In 1994, BNL was notified that the fuel canal did not meet applicable storage tank requirements; monitoring wells were installed in 1996.

In 1994, this issue was once again considered by BNL. A work order (referred to at BNL as an activity data sheet) stated that "early detection of canal leakage will enable action before the contamination plume reaches the public water supply." Also in 1994, the Suffolk County Department of Health Services (SCDHS) conducted an inspection and identified a number of storage facilities that required regulation under Article 12 of the Sanitary Code; that list included the fuel storage canal (Tank 750-11). The fuel canal was considered a storage tank without secondary containment, and a commitment was made to SCDHS to install down gradient monitoring wells at HFBR by 1995. Funding reductions resulted in delays in installation until July 1996. Sampling occurred in October 1996, and initial analysis took place in December 1996.

> ➪ HFBR was not considered a priority compared to known sources of contamination.

As the chronology of events indicates, about four years elapsed between the time when the need for monitoring of the HFBR was identified in 1992 and the time when it was implemented in late 1996. The reasons for the delays in installing groundwater monitoring wells south of HFBR are complex, and in some respects understandable given the historical approach to groundwater monitoring at BNL. The historical approach has been to focus groundwater monitoring on known contamination facilities, such as the Hazardous Waste

BNL is located close to the geographic center of Suffolk County on Long Island, about 60 miles east of New York City. Although much of the land area adjacent to the site remains forested or cultivated, there has been an increase in residential housing development in rural areas surrounding BNL. According to the Long Island Regional Planning Board and Suffolk County, BNL is situated over a deep flow recharge zone for the Nassau/Suffolk Aquifer System on Long Island. The EPA has designated this System as a Sole Source Aquifer under the Safe Drinking Water Act. The general near-surface groundwater flow under the BNL site is from north to south. The Laboratory site lies on the western rim of the shallow Peconic River water shed. The Peconic River is classified as an intermittent river because it both recharges to and receives water from the groundwater aquifer, depending on the hydrological potential. Therefore, releases to surface water or the ground surface occurring at BNL have the potential to impact both onsite and offsite groundwater drinking water supplies.

There has been a history of chemical and radiological releases to surface water and groundwater on the BNL site. Historical releases of volatile organic compounds and other materials have contaminated the groundwater on site, and to the southeast and south of the site. As a result, BNL was listed on the National Priority List (NPL) on November 21, 1989. Under a 1992 Federal Facility Interagency Agreement between DOE, EPA, and the New York State Department of Environmental Conservation under the Comprehensive Environmental Response Compensation Liability Act (CERCLA), ongoing remedial investigations are continuing to define future cleanup priorities associated with various former landfills, the waste management facility, the leaking sanitary sewage collection system, and the sewage treatment plant. In recent years, the focus has been on addressing high priority response actions to provide public water hook up to homes south of the site, to cap inactive landfills, to remove underground storage tanks, to excavate cesspools, to remove above-ground radiological waste tanks, and to install a groundwater pump and treat system to minimize any additional offsite contamination.

In addition to the restoration program, BNL is required by DOE orders to establish an environmental protection program, including effluent monitoring and environmental surveillance. DOE requires monitoring of groundwater that is or could be affected by site activities to determine the effects of operations on groundwater quality and to demonstrate compliance with applicable Federal, state, and local laws and regulations. For example, there are over 200 storage facilities at BNL that are regulated under Suffolk County Sanitary Code Articles 7 and 12, which define requirements, including groundwater monitoring, for storage of hazardous materials in tanks. Since the signing of an agreement between Suffolk County and BNL in 1987, the Laboratory has been moving to bring these storage facilities into compliance.

Elevated levels of tritium have been found in various locations at the BNL site and in offsite wells. Historic sources of onsite groundwater tritium contamination include the Waste Concentration Facility, which is now under remediation. The highest detected concentrations associated with the Waste Concentration Facility plume have been in the range of 5,000 picocuries per liter (pCi/L). (A pCi is 10^{-12} Curies, and a Curie is a measure of radiation defined as 3.7×10^{10} disintegrations per second.) The historical concentrations of tritium in the Waste Concentration Facility plume are less than the drinking water standard (20,000 pCi/L) and much less than the concentrations recently found adjacent to the HFBR.

In late 1984 and early 1985, a groundwater contaminant plume consisting of elevated concentrations of tritium was discovered at the eastern border of the BNL site and in offsite residential wells. The tritium levels in offsite residential wells have been below the EPA drinking water standards. This off-site plume has been attributed to documented releases from the Waste Concentration Facility to the Sewage Treatment Plant, which discharges to the Peconic River, and possibly to sources such as the Hazardous Waste Management Facility and the current and former landfills. Onsite groundwater tritium concentrations in these areas have been as high as 80,000 pCi/L.

Onsite potable water supply wells are being specifically addressed under the long-term CERCLA remedial investigation activities. Results from daily analysis of the onsite drinking water distribution system and quarterly samples from active drinking water supplies located north (up gradient) of HFBR show that this water is not contaminated with tritium, and the supplies are not perceived to be at risk.

The BNL groundwater monitoring and surveillance program has been significantly expanded and substantially improved over the last five years. These efforts, which represent the combined efforts of both BNL and DOE, include over 500 permanent monitoring wells across the site and a number of offsite wells, 350 annual surveillances, and a strong focus on known contamination sources.

Figure 3. Background on BNL Environmental Restoration and Environmental Monitoring Programs.

1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993

•September 9, 1987
Agreement between BNL and Suffolk County. Agreement includes Article 12 of Suffolk Country Sanitary Code.

•November 9, 1988
DOE Order 5400.1 requires Groundwater Management Program to include a groundwater monitoring program

•June, 1990
Tiger Team finding on characterization of BNL's groundwater

•February 5, 1992
NRC 92-11 Notice on soil and water contamination at fuel cycle facilities

•April 2, 1992
BNL memorandum on NRC Notice discusses checking for leakage from the canal and monitoring wells

•July 7, 1993
BNL S&EP memorandum discusses Article 12 requirements for secondary containment and leak detection systems, and states need for monitoring wells.

Jan | 1994 | Dec

•January 6, 1994
Work orders for monitoring wells prepared.

•August 4, 1994
Inspection of storage tanks conducted by SCDHS.

•August 9, 1994
Suffolk County letter to BHG found violation of Article 12 for storage tanks and that the SCDHS requirements for the fuel canal would be "remove or abandon in place."

•October 17, 1994
Suffolk County letter to BHG stated the fuel canal "Must be removed or abandoned in place."

•October 18, 1994
Memorandum from BNL to DOE on Article 12 commits to develop plans to bring facilities into compliance to be completed by December 1, 1994, at which time funding sources will be sought.

•November 14, 1994
Quarterly meeting between SCDHS, BNL, and BHG personnel. Document entitled *Summary of Article 12 Non-Compliant Tank Inventory by Departments* was presented. Canal presented as unfunded requirement.

•December 30, 1994
Work order to put in wells by February 1, 1995.

Jan | 1995 | Dec | Jan | 1996 | Dec

•March 3, 1995
Meeting between SCDHS, BNL, and BHG personnel. Canal presented as deficient for secondary containment with "monitoring wells to be installed down gradient for monitoring of potential leakage, Project in effect." Planning completion date showed August 1995 start.

•June 30, 1995
Monitoring wells held up due to budget reduction.

•January 24, 1996
BNL memorandum on need for the installation of monitoring wells. Discusses SCDHS requirement for wells at HFBR

•February 15, 1996
Mtg. between SCDHS, BNL, and BHG. Installation of monitoring wells down gradient of the HFBR - Year of Completion 1996

•March 1, 1996
Work orders to install monitoring wells

•Sept. 20, 1996
Work orders shows date closed as September 20, 1996

•Oct. 17, 1996
First sample taken from groundwater monitoring wells

•Dec. 5, 1996
Analysis show 2,520 pCi/L tritium concentrations for Well 75-12 and 454 pCi/L tritium concentrations for Well 75-11

Jan 1 | 1997 | Feb 14

•January 8, 1997
Analytical results show 44,700 pCi/L tritium concentrations for Well 75-12, and 2,110 pCi/L tritium concentrations for Well 75-11 (tritium above drinking water standards)

•January 18, 1997
BNL announces tritium contamination at HFBR

•January 23, 1997
Initiated Phase I of geoprobe at HFBR facility; EPA duplicate samples taken

•January 27, 1997
Initiated Phase II of geoprobe approximately 400 feet south of HFBR

•January 29, 1997
Revised HFBR Tritium Plume Recovery Plan - Rev 0

•January 31, 1997
Press release of sampling results

•January 31, 1997
BNL meeting with EPA

•February 5, 1997
BHG Direction Letter to BNL

•February 5, 1997
BNL meeting with EPA, state, and county regulators

•February 5, 1997
Raytheon Corporation to assist BNL in evaluating fuel canal

•February 5, 1997
Resampling of onsite and offsite permanent wells for tritium

•February 6, 1997
Initiated planning for installation of liner in fuel canal

•February 6, 1997
Updated press release: Tritium - 32 times drinking water standard

•February 6, 1997
First EPA tritium results received; good agreement with BNL results

•February 7, 1997
Results of tritium sampling in onsite and offsite wells

•February 7, 1997
Initiated planning for mitigation of HFBR plume

•February 7, 1997
Initiated Phase III of geoprobes at 1000 feet south of HFBR

•February 14, 1997
Completion of EH Oversight review

Figure 4. Timeline for Groundwater Monitoring Wells and Detection of Tritium at HFBR

Management Facility, the Sewage Treatment Plant, and several landfills, and at the site boundary. This is a credible approach in the initial stages of site cleanup and environmental restoration. From an individual facility standpoint, HFBR was apparently not considered a high probability to impact groundwater quality or to warrant expenditure of reactor operating funds on monitoring wells; reactors are designed to have a high level of containment integrity, so that any potential effluent would be monitored and detected. In addition, unlike the monitoring wells installed as part of the restoration program, the sitewide groundwater monitoring program at BNL is funded out of overhead or landlord funding, placing it in competition with funding for other important site activities, such as building maintenance, new construction, and purchase of equipment.

➯ The prioritization analysis did not consider important information.

There are, however, a number of problems associated with the apparent assumptions that led to a low priority for the HFBR groundwater monitoring. These include:

- The 33-year-old concrete fuel canal was built in accordance with design requirements at the time, but does not have provisions for secondary containment as required by current standards. Pre-construction engineering design calculations in 1963 indicated that the permeability of the concrete in the fuel canal could result in leakage of 3 to 8 gallons per day from the canal.

- There was no comprehensive HFBR tritium monitoring program that addressed potential sources, such as the secondary cooling side of the fuel canal heat exchanger. Poor maintenance practices and containment allowed primary coolant to spill out onto the reactor building floor from a primary coolant pump seal in 1995.

There were known problems with building sealant material, which had to be repaired periodically for the annual confinement test. The inspection program did not fully address floor seams, pipe penetrations, or other areas that contained this sealant material.

There was a history of leaking sanitary sewer pipes in the area around HFBR, and monitoring for tritium was not comprehensive (performed only on a batch sample basis at main trunk lines).

There was an increase in tritium levels in the fuel canal in 1995 without timely actions to determine the cause(s) or to reduce the levels to limit the impact of a potential leak on groundwater.

➯ A rigorous sitewide prioritization approach was not fully implemented.

These examples help illustrate that at HFBR there were credible reasons to suspect that tritium or other hazardous material (e.g., fission products in the coolant) could leak to the environment. They also help to explain the difficulties being encountered in identifying and isolating the source of this plume. It is not possible to say whether consideration of these factors would have resulted in different decisions about the priority of HFBR groundwater monitoring in light of BNL's focus on known or suspected contamination sites and the site boundary. However, it appears as though BNL did not rigorously analyze the potential for releases from the HFBR and was somewhat overconfident in the control of effluents from the HFBR. In addition, an independent study in the late 1980s recommended more emphasis on a sitewide hydrogeological approach to the prioritization of monitoring; however, this approach was not fully implemented.

More timely action by BNL to monitor groundwater south of HFBR and to better monitor and control effluents could have identified the tritium plume sooner and helped mitigate groundwater contamination. In addition, earlier installation of monitoring wells and better operational controls (e.g., evaluation of elevated tritium levels in the fuel canal and better maintenance procedures) could have made identification and resolution of the tritium leak source much less challenging.

➪ Senior managers were not sufficiently involved in the decision processes and did not have the necessary information.

Based on the information available to date, it appears that many of the decisions about HFBR groundwater monitoring were made within lower levels of the BNL organization. Communications between various BNL organizations (e.g., between the Reactor Division and the Safety and Environmental Protection Division) and communications among BNL, the DOE Chicago Operations Office (CH), and the CH Brookhaven Group (BHG) were not as effective as they should have been. Senior managers were not sufficiently involved in the decision processes and may not have had all the information necessary to make good decisions about the priority of HFBR monitoring. Interviews with BHG and BNL managers indicate that elevation of the decisions to a higher level of BNL and DOE management could have resulted in more timely action.

➪ Apparent weaknesses in planning and prioritization will be evaluated in the next phase, recognizing the improvements in the sitewide environmental protection program.

The chronology indicates some weaknesses in the DOE and BNL approach to issues management, planning, and prioritization; these issues will be a focus of the upcoming Oversight safety management evaluation. However, it is important to recognize that the decisions leading to delays in monitoring groundwater were made within the context of other sitewide environmental concerns that were formally prioritized. Within the past five years, there have been significant actions taken to improve the environmental protection program at BNL, with primary emphasis on the site boundary and known sources of contamination.

3.0 CURRENT BNL INITIATIVES

Overview of Actions Since Detection of Elevated Tritium Levels

➪ The HFBR remains shut down pending resolution of the plume.

As shown in the timeline (Figure 4), in December 1996 BNL reported through the DOE Occurrence Reporting and Processing System (ORPS) that groundwater monitoring adjacent to the HFBR indicated the presence of tritium. Subsequent samplings in January indicated levels above the EPA's 20,000 picocuries per liter (pCi/L) drinking water standard in the groundwater near the reactor. As of February 7, 1997, peak concentrations in groundwater as high as 651,000 pCi/L, which is approximately 32 times the drinking water standard, have been detected in geoprobe samples collected adjacent to the HFBR. The BNL sample analyses have been confirmed as accurate by duplicate sampling by the EPA; the HFBR remains shut down pending resolution of the tritium plume. The wells are not near any drinking water supply, and the plume is does not extend to any drinking water sources.

Since concentrations of tritium in excess of drinking water standards were identified on January 8, 1997, BHG and BNL have been actively identifying mechanisms to address the matter. The initial actions included re-sampling to verify results, notifying interested parties (e.g., CH, DOE Headquarters, the EPA, New York State Department of Environmental Conservation, SCDHS, local community leaders, BNL staff, and the public), maintaining the reactor shut down (at the time the contamination was detected, the reactor was shut down for routine refueling) until the situation is resolved, and initiating the geoprobe investigation.

➪ The revised BNL recovery plan is a positive step to address the tritium contamination.

On January 28, 1997, BNL restructured the plume recovery team, established a management review group, and formulated a revised recovery plan. The revised plan, entitled *HFBR Tritium Plume Recovery Plan*, was approved by BNL and BHG management on January 29, 1997. The plan describes BNL's approach and management responsibilities, and identifies the near-term and longer-term activities that BNL will take to address the tritium contamination problem. Oversight views this restructuring as a positive action that more clearly defines the necessary near-term and longer-term actions to resolve this situation including identification of specific responsibilities. BNL's revised approach also serves to better integrate and coordinate essential sitewide resources and organizations to achieve the objectives, which include: identifying and resolving the tritium source(s), identifying the extent and magnitude of the tritium plume, investigating and modeling groundwater, sampling and analyzing groundwater, and identifying and implementing actions to mitigate and remediate the tritium plume.

As groundwater monitoring at the HFBR has shown higher concentrations of tritium, the Department's expectations for more rapidly implementing corrective actions has been communicated to BNL (most visibly in a February 5, 1997, BHG letter to BNL identifying specific deliverables that were required). On February 5, 1997, BNL responded to the Department's letter and indicated the status of actions taken and planned. Figure 5 provides a summary of key elements of the BNL plan and the options that are being considered for plume recovery.

Tritium Source Identification and Resolution

➪ The primary focus has been on determining the source of the contamination.

Investigation of the tritium plume source was the major focus of the BNL HFBR Tritium Plume Recovery Team during this interim EH Oversight evaluation. BNL has analyzed the potential locations where tritium could leak to the environment without timely detection. Based on a number of factors (e.g., the results of the monitoring indicated contamination levels significantly higher than previous experience, the contamination was in the immediate vicinity of the reactor, contamination is near the top of the groundwater, and no other monitoring points indicated unusual levels), BNL rapidly reached the conclusion that the source of tritium must be from within the HFBR building.

➪ The primary coolant is not viewed as a likely source because of the reactor design features.

Based on the magnitude of the contamination detected in the monitoring wells, BNL has concluded that there are three possible sources: (1) the primary coolant piping and other piping containing heavy water (D_2O), (2) the spent fuel canal, and (3) spills or leaks of water containing tritium, which could leak through the floor of the reactor building (e.g., through seams adjacent to pipe penetrations,

BNL Plan Steps to Plume Mitigation

1. **Source Elimination:** As of the date of this report, all evidence points to the HFBR as the source of the tritium, although the type, mechanism, and location of the leak (or leaks) are not fully known. Since these uncertainties exist, the impact that a proactive effort to eliminate the source will have is inherently uncertain. At the moment, a horizontal drilling effort is being planned which will involve completing a boring that will target soil above the water table that underlies the canal. This boring will be targeted to intersect a zone of potentially high contamination. It has been designed to enhance the understanding of source release and may be used to extract any contamination that would otherwise end up migrating downward into groundwater.

2. **Fully Define Extent of Contamination:** The Phase III geoprobe program is the latest effort to define the extent of contamination. But as tritium migrates farther from the source, the potential for tritium to migrate to depths that exceed the reach of geoprobes increases. As a consequence, once Phase III is complete, BNL has elected to install a series of groundwater profile wells. These wells are able to evaluate deeper portions of the aquifer, to ensure that no portion of the plume goes undetected. BNL initially plans to install a total of eight wells to track the plume, although the number of wells may increase. These wells may also be used to extract contaminated groundwater should extraction be chosen as part of the remedial action.

3. **Establish Groundwater Cleanup Levels:** There are several groundwater cleanup levels that need to be determined as plume remediation is designed and implemented. For example, the concentrations that are acceptable at the site boundary need to be established, in the event that transport modeling indicates that the plume could migrate that distance.

4. **Collect Information to Select Remedial Action:** Information needed to support the evaluation and selection of a remedial action includes water gradient (vertical and horizontal) information; plume delineation; cleanup goals; treatment/disposal options; risk determination; community concerns; costs; and groundwater modeling.

5. **Identify and Evaluate Remedial Actions:** Five options have been identified as being potentially effective at mitigating the plume: a) extraction and treatment/disposal; b) extraction and recirculation; c) plume immobilization; d) containment/stabilization using barriers; and e) no action.
   - **a. Extraction of tritiated water with treatment/disposal:** In this alternative, the most highly contaminated groundwater would be pumped from the ground at low flow rate, so that the disturbance to surrounding groundwater flow is minimized. The pumpage would be stored, treated, or disposed of in an acceptable manner.
   - **b. Extraction of tritiated water with recirculation:** Extraction wells would be placed at the down gradient end of the contaminated area, and the contaminated groundwater would be reinjected up gradient near the source. This results in the continual circulation the contaminated groundwater within a restricted volume of the aquifer, where it is held until the tritium decays to low concentrations.
   - **c. Immobilization of the plume:** Manage the plume by capping the area of contamination with an impermeable layer to eliminate recharge, and the horizontal groundwater gradient would be flattened by locating pumping wells up gradient of the source. Piezometers would be used for monitoring to assure that contaminated groundwater is not escaping. Head data collected from piezometers would be utilized to assure that a zero gradient condition is maintained.
   - **d. Containment/stabilization through installation of barriers:** Several barrier types exist that may be effective in containing the high concentration tritiated groundwater. These types include high pressure injected grouts and polymers, as well as freeze walls. Impermeable barriers and an engineered treatment zone or wall can be installed in a “funnel and gate” configuration. In this configuration, contaminated groundwater is captured by the funnel as it flows along the natural hydraulic gradient. The funnel diverts the contaminated groundwater through the gate, where contaminant extraction takes place.
   - **e. No action:** Because there is no immediate health risk to either the public or onsite workers, a no-action alternative will be evaluated. Piezometer and well monitoring coupled with groundwater and transport modeling could prove that long term risk is also acceptably low. It is possible that the tritium plume will attenuate before it can reach down gradient receptors due to dilution and decay.

Figure 5. Summary of BNL Plans To Remediate the HFBR Tritium Plume

joints in the floor, cracks, or other leak paths). Although analysis continues, BNL views the first of these three sources as less likely because of the design features of the primary coolant/ heavy water systems. These design features include stainless steel construction, two independent means of leak testing, in-line tritium monitors, stringent water chemistry controls, and other engineering features; BNL's preliminary analysis indicates that these features are sufficient to prevent an undetected loss of heavy water of the magnitude necessary to cause the level of contamination being experienced at the HFBR.

➪ Two sources are most credible, the fuel canal and a 1995 coolant pump seal failure that discharged heavy water to the reactor building.

The more recent samples (which indicate a higher concentration of tritium than the initial samples) have allowed BNL to better qualitatively estimate a lower bound on the amount of tritium that must have leaked to the groundwater. These additional analyses have focused attention on two specific sources. One is the fuel storage canal, and the other is a 1995 primary coolant pump seal failure that resulted in discharge of primary coolant to the reactor building equipment level basement. In the 1995 pump seal failure, a portion of heavy water went unrecovered during the cleanup effort. Some of the unrecovered spill evaporated, but some may have leaked through floor penetrations or seams. Tests conducted by BNL indicate that some of the heavy water could have drained though concrete or seals around capped penetrations, which drain to a unknown locations in or under the reactor building floor.

➪ BNL's analysis methods have become more systematic and rigorous.

The team has observed the BNL investigation of these two potential tritium sources, including video inspection of the fuel canal walls; a test to determine leakage rate from a small simulated spill in the area of the 1995 seal leak; and methods aimed at detecting the lower band of fuel canal leakage. Initial BNL efforts involved "brainstorming" sessions that generated many ideas. As the evaluation progressed and the management approach was restructured, BNL's approaches became more rigorous and systematic.

➪ A conclusive determination of the source has not been achieved.

During the period of this review, none of these efforts were conclusive, and other approaches to source identification are under consideration. Examples include:

- Use of trace chemicals to test various possible pathways
- Directional drilling and soil sampling under the fuel canal in the reactor building to determine the location of contamination to help localize the leak (e.g., samples from under the fuel canal may verify or eliminate it as a contributor)
- Drilling holes in the reactor building floor and sampling to determine the distribution of contamination and thus localize the source
- Additional leak testing around reactor building floor and drain seals.

Several options were also under consideration for source resolution, including lowering the spent fuel canal water level, the installation of a fuel canal liner and leak detection system, and the shipping of additional spent fuel currently stored in the canal. EH believes that more aggressive planning and preparation for the installation of a fuel canal liner and shipping of additional spent fuel to Savannah River in 1997 are important elements of eliminating the fuel canal as an actual or potential source for tritium in the groundwater.

➪ Hazards associated with options under consideration need to be fully analyzed.

Recognizing that there is pressure to take timely action to identify and resolve the source, the Review Team believes that options should be fully analyzed before they are implemented. A number of the options under consideration represent risks in and of themselves. For example, drilling through the reactor building floor could cause structural damage to the containment; thus an effort to localize the tritium could entail a degradation in reactor safety if not done properly. Such actions could also represent unreviewed safety questions that must be formally addressed. Drilling operations (either through the floor or directional drilling) should also consider worker and facility safety hazards, such as severing piping or electric lines. These concerns are heightened by the fact that most HFBR and in-ground utility drawings are 30-year-old design drawings and may not be reflective of the as-built equipment and structures. Further, directional drilling could create water transfer pathways that may preclude future use of options such as tracers because it biases the samples.

➪ Options to control the source also require additional analysis.

In addition, options to control or resolve the source need to be fully analyzed. For example, lowering the spent fuel canal level could result in increased exposure to workers (the increase in radiation exposure depends on how much the level is lowered), and installation of a fuel canal liner would involve worker exposure during the installation process. Along with the understandable desire to identify and control the tritium source, BNL and DOE managers need to have an accurate understanding of the potential hazards as well as the potential benefits of each option to assure that the options selected are the most effective and efficient, and that the associated hazards and risks to workers and the environment are clearly understood, accepted, and properly mitigated and controlled. (See the third item in Section 4, "Opportunities for Improvement.")

➪ The efforts to identify the source are currently aggressive and systematic.

Although far from complete, the source investigation effort by BNL is aggressive. In the early stages of the review, the Review Team had a concern that the source resolution effort involved the participation of a number of individuals and generated many ideas but was lacking in actual planning and preparation. However, the revised plan helped promote a more systematic approach and the intensity of the effort appeared to accelerate with the issuance of the February 5, 1997 letter from BHG to the BNL Director.

Groundwater Investigation and Plume Recovery

➪ Efforts to determine the extent of the plume and groundwater flows have been effective.

The groundwater investigation effort by BNL was observed to be appropriately aggressive during the duration of the interim Oversight review. The initial elevated tritium levels detected in the two permanent monitoring wells south of HFBR have been supplemented by a large number of geoprobe samples. Actions to characterize and model groundwater flows, a necessary step in determining the most effective remediation options, have been initiated; potential remediation options have been identified and preliminary analyses performed for those options.

➪ Three phases of geoprobe sampling have been performed.

Three phases of geoprobe-based characterization have been implemented since tritium was initially detected in the two groundwater monitoring wells. During Phases I and II, a total of 24 geoprobe locations were utilized to collect 110 groundwater samples. The samples were analyzed for tritium to determine the vertical profile and spatial distribution of contamination detected around the HFBR. Phase III results are anticipated to be available about February 14, 1997. When complete, the Phases I, II, and III geoprobes will help to characterize an area that extends from just south of the reactor building in a south-southwest direction as far as Brookhaven Avenue (approximately 1100 ft south).

➪ The geoprobe sampling has helped to define the extent of the plume.

Although Phase III results are forthcoming, the geoprobes are already assisting in better defining the tritium plume, and are essential elements in determining the proper mitigation and remediation actions. Four Phase I probes installed north (up gradient) of the HFBR tested at less than the minimum detection limit for tritium, implying that the tritium is originating solely from the HFBR. The remaining characterization during Phases I and II involved geoprobing at twenty locations, ranging from 100 ft to 400 ft down gradient of the HFBR. These results indicate that the tritium plume exists down gradient of the HFBR and originates from that facility. The plume was found to extend down gradient past the southernmost Phase II locations (approximately 400 ft south of HFBR, along Temple Place).

As part of ongoing remediation efforts, BNL has tasked a subcontractor to construct a comprehensive regional groundwater model that covers the BNL site and surrounding areas. The intent of this model is to help ensure that environmental impacts associated with past and present activities at BNL are thoroughly and adequately investigated so that appropriate response actions can be formulated, assessed, and implemented.

At the start of the EH Oversight review, BNL efforts to characterize the plume and plan for remediation were still essentially in the conceptual stages. The new BNL HFBR Tritium Recovery Plan, the DOE letter to BNL requesting expediting of recovery actions, and DOE Headquarters direction to accelerate plume mitigation efforts have improved the focus and pace of the BNL efforts.

➪ BNL has appropriately identified the options to recover the plume.

BNL, in conjunction with DOE, has analyzed options and developed an approach to recover the tritium plume. The options under consideration adequately cover the spectrum of possible approaches. The final selection of a tritium plume remediation option will necessarily be based on a number of factors, including feasibility, effectiveness, regulations and permits, and environmental impact.

➪ There is no need to delay recovery until after the source is conclusively identified.

During the review there were indications that some BNL personnel believed that planning and implementing plume recovery efforts should wait until after the source was identified and resolved. In the interest of protecting the sole source aquifer and alleviating public concern, the selection, planning, preparation, and implementation should be accomplished as soon as possible. There is no apparent need to delay plume recovery efforts until the source is identified and resolved.

BNL has been in contact with a number of other DOE and commercial organizations that have experience in plume mitigation and recovery technologies. DOE sites with extensive experience in leak source detection and groundwater plume control, such as Hanford, should also be considered as potential sources of advice and assistance. As with source investigation and resolution, enhancements should be considered to the systems management review and approval processes to ensure that BNL and DOE management review have comprehensive and current information available for the decision making process.

Groundwater Sampling and Analysis Techniques

➪ Numerous samples have been analyzed.

In support of the effort to better define the tritium plume, groundwater sampling south of HFBR increased significantly since concentrations above the drinking water standard were identified in early January 1997. Numerous samples were being analyzed down gradient of the HFBR as well as from locations farther south, including the site boundary and in offsite residential communities. Geoprobes have been utilized to quickly obtain plume samples, and both permanent wells and geoprobes are being used to obtain samples at other locations. These geoprobes will be supplemented by vertical profile wells and eventually by additional permanent monitoring wells once the plume is better profiled.

➪ The samples were appropriately analyzed.

The permanent wells are being sampled according to approved standard operating procedures. Because of the need to collect samples quickly after concentrations in excess of the standards were identified, BNL did not initially develop a formal sampling plan for taking samples with the geoprobes. However, Oversight's review of the sampling processes and methods indicates that both the permanent and geoprobe samples result in accurate values for the tritium concentrations. The EH Oversight team observed and evaluated sampling analyses by the BNL analytical laboratory (i.e., Analytical Services Laboratory) on a number of occasions. The analyses were conducted appropriately and in accordance with EPA procedures.

➪ BNL results agree well with those of the Environmental Protection Agency and Suffolk County.

The EPA performs independent analysis of BNL's duplicate samples, and also independently takes random samples for analysis. The tritium analysis results for the first 45 duplicate samples performed by BNL and the EPA agree well and are within overall statistical uncertainties. Additionally, SCDHS routinely obtains duplicate drinking water samples from offsite private wells. The results of duplicate samples (which were analyzed by the New York State Department of Health) agree well with BNL's results (within statistical limits).

➪ Appropriate methods are used to analyze samples.

BNL's analytical laboratory uses appropriate methods (EPA Method 906.0) for sampling and analyzing the groundwater to determine the concentration of tritium. However, the specific EPA method has not been formally documented in the BNL analytical laboratory procedures. The methods involve placing a distilled sample into a counting solution and using a liquid scintillation counter because tritium emits only low energy beta particles that cannot be detected by normal radiological instruments (e.g., Geiger counter). The methods used by BNL are capable of detecting concentrations within the 300 to 500 pCi/L range, which is well under the required EPA detection limit (1000 pCi/L). BNL's internal quality assurance methods (which include daily evaluations of the detection equipment and use of control charts) are adequate to ensure that BNL meets the EPA detection limit and produces representative results.

➪ BNL's analytical laboratory is certified and participates in cross check programs.

BNL's Analytical Services Laboratory is certified by the State of New York State Department of Health's Environmental Laboratory Approval Program for analysis of tritium in drinking water. They also participate in DOE and EPA inter-laboratory cross check programs. In recent years, BNL's analysis of tritium samples has been well within the accepted range in almost all cases. Although some weaknesses were noted in these cross checks (e.g., in one recent case, BNL did not correctly apply a dilution factor), BNL's analytical laboratory generally performs well, particularly on techniques that it performs routinely, such as tritium measurements of water samples. Also, BNL uses the lessons learned in these cross checks to improve its analysis program.

➪ BNL is establishing appropriate controls for using outside laboratories to analyze additional samples.

The recent increase in the number of samples, combined with demands of rapid turnaround, has placed significant demands on the resources of the BNL analytical laboratory. An attempt to outsource some of these analyses to an outside organization was halted because of certification issues. BNL now plans to use two outside contractor laboratories, both of which are certified, for support in analysis of samples. BNL has established specific conditions and requirements for these laboratories (i.e., they must be able to perform analysis according to the EPA methods, be certified by New York State Department of Health, and have acceptable performance in recent EPA and/or DOE tritium analysis cross checks). BNL will also send these laboratories known spiked and blank samples to verify the accuracy of results and will maintain duplicate samples to enable future reanalysis as needed.

Overall Assessment of BNL Initiatives

➪ The plume is not an immediate threat to drinking water.

At the time of this review, the tritium plume appears to be relatively shallow and about 1.3 miles from the southern site boundary. It does not pose an immediate threat to drinking water, workers, or the public. At the same time, Long Island is a densely populated area, and BNL site, private, and public water supplies are from a sole source aquifer. It is therefore important to expedite plans and actions to begin remediation of this plume without waiting for source identification and resolution.

➪ BNL's initial response to the issue was not well coordinated.

When it first became evident that there was a significant contamination problem (in the December 1996 to early January 1997 timeframe), BNL's response was somewhat disjointed. For example, a number of different individuals and organizations were providing input and identifying options, but a coordinated management approach to systematically addressing the issue was not evident. In addition, BNL first attempted to address the issue internally, and did not request assistance from other organizations that had faced similar problems.

➪ The revised plan is responsive to the problems and public and stakeholder concerns.

Despite these early coordination problems, BNL and DOE, including Headquarters, CH, and BHG, are combining resources and working together toward a timely and effective resolution. BNL's decision to restructure the recovery team and revise the HFBR Tritium Plume Recovery Plan represents a positive action. The revised plan more clearly defines necessary near-term and longer-term actions, defines specific roles and responsibilities, and better integrates sitewide resources and organizations into the recovery effort. The results of this evaluation indicate that the approach to the recovery of the HFBR tritium plume, particularly since late January 1997 when BNL restructured its management approach to resolution of this issue, is responsive to the problem as well as to public and stakeholder interests and concerns.

➪ Additional assistance from other DOE sites may be beneficial.

As a number of alternative recovery options are considered, it is important that existing experience and technologies from other DOE sites as well as commercial sources be utilized as effectively as possible. While some other DOE and commercial organizations have been contacted, other sites that have not been asked to assist (e.g., Hanford) have considerable experience with leak detection and groundwater plume control and remediation. It is also very important that BNL and DOE management review and approval processes be established to evaluate the safety implications, effectiveness, and long-term impacts of selected strategies prior to implementation (see the third item in Section 4, "Opportunities for Improvement").

➪ BNL and DOE actions since late January have been aggressive and appropriate.

Although many improvements have been accomplished in environmental management and groundwater monitoring by BNL, there was a significant delay in the implementation of groundwater monitoring at the HFBR once a need was identified, and BNL did not fully analyze the potential for releases to the environment at the HFBR. There were also some initial problems in developing a coordinated approach to resolving the issue once contamination was identified in early January 1997. However, the actions of both BNL and DOE since late January have been aggressive and appropriate.

4.0 OPPORTUNITIES FOR IMPROVEMENT

The following are opportunities for improvement identified during the EH Oversight groundwater review. Because of the pace of developments on these issues, these potential improvements have been presented to BNL, and some of these opportunities may already be under consideration by BNL.

1. Expedite planning, preparation, and decisions related to tritium plume source resolution.

The high levels of tritium being detected in the HFBR tritium plume have narrowed the suspect plume sources to two, the fuel canal and the 1995 primary coolant pump seal leak. Since the determination and confirmation of which is the actual leak source may take considerable time, the planning, preparation, and decisions to resolve both sources should be pursued. This is important because of the lead time necessary to procure equipment and services, perform safety analyses, obtain regulator approvals and permits, and arrange project funding. Although planning and preparation should be expedited, it is equally important that decisions to proceed with work be made according to a structured decision process (see the third opportunity for improvement). The review team has noted that much of the BNL effort is focused on determining which of the two likely sources is causing the problem. While this information may be useful, the review team believes that both possible sources need to be addressed. Therefore, planning actions to resolve both potential sources should not be delayed while BNL attempts to determine the actual source. By planning actions in an expedited manner, BNL will be better prepared to implement actions in a timely manner when decisions are finalized and approved. Specific actions that should be considered include:

- Pursue planning, preparation, and decisions related to the installation of a fuel canal liner (including a leak detection system to detection leakage to the liner).

- Evaluate the feasibility of shipping additional spent fuel off site in 1997 to lower spent fuel inventories and facilitate liner installation if that is deemed necessary. (Liner installation may require shipping all fuel off site; shipping some as soon as feasible will help expedite this process if a liner installation is necessary.)

- Determine all potential sources of HFBR effluents and implement continuous in-line tritium monitoring.

- Upgrade, maintain, and inspect reactor building sealing, including building seams and floor penetrations and drain plugs.

- Conduct an engineering evaluation to ensure that there are no other points between the equipment cells and operating spaces that result in uncontrolled releases of heavy water to the reactor building.

- Implement actions to reduce and control tritium levels in the spent fuel canal (while ensuring that the actions taken to not result in ALARA issues or excessive exposure to workers).

2. Expedite planning, preparation, and implementation of mitigation and remediation of the tritium plume.

Although the HFBR tritium plume does not represent an immediate public or worker health concern, public anxiety resulting from the increasing reported levels and the perceived potential impact on the sole source aquifer is growing quickly. Efforts to mitigate and remediate this plume, therefore, should be expedited and should not be delayed until source identification is completed. Actions that should be considered include:

- Because of the long lead times to obtain equipment and approvals, it is important to begin planning and preparation for groundwater pumping (e.g., equipment, safety analysis, permits, and schedules), even though pumping may or may not be the option that is ultimately selected.

- It is also important to explore the feasibility and advisability for each of the options under consideration for handling and disposition of the tritiated water once recovered.

- Regardless of which option is selected, continued and increased attention is needed to obtain regulator approvals and stakeholder acceptance and understanding of the proposed approach to tritium plume recovery and disposition.

3. Assure a structured BNL and DOE management review and approval process for decisions related to source investigation and resolution as well as plume mitigation and remediation.

The pressures and aggressive schedules involved with the tritium plume recovery, as well as the many options available, create the potential for decisions that may carry risks, that may not be the most effective options available, or that might not be supportive of BNL, DOE, or stakeholder interests. It is essential that there be a structured and effective BNL and DOE management review and approval of these proposals before implementation. It is critical that thorough and effective hazard analysis be part of the decision process, and that senior managers (representing CH, BHG, BNL, and the Headquarters Offices of Energy

Research, Environmental Management, and Nuclear Energy) are provided with the information necessary to make good decisions. As discussed previously, the review team has noted that some of the actions being considered, such as directional drilling under the HFBR containment building, may involve hazards that have not been fully analyzed. Actions that should be considered include:

- BNL should separate Tritium Plume Recovery working group "brainstorming" sessions from the decisionmaking processes. Recommendations of working groups should go forward as proposals to appropriate levels of BNL and DOE management for review and approval.

- Plume Recovery Team members presenting options to the management review committee should be prepared to address the advantages over other options, risks and safety measures, costs and benefits, schedule, barriers including regulatory requirements, and demonstration that the technology has been successful at other DOE sites or in related industries.

- A senior management review committee, consisting of appropriate managers from BNL, BHG, CH, and Headquarters, should evaluate these proposals as a body, including risks and safety measures, feasibility, cost-benefit, and compatibility with Laboratory, DOE, and stakeholder short- and long-term objectives and goals.

- Records of review, approval, and decisions of the senior management review committee should be maintained as permanent records.

4. The lessons learned from this event and the historical chronology should be used to improve the BNL groundwater monitoring and remediation programs.

The historical chronology of groundwater monitoring associated with the HFBR indicates that the need for monitoring wells south of the reactor was identified as early as 1992 and was raised as an issue again in 1994. However, the methods used establish environmental restoration priorities (i.e., focusing on known contamination sources and on potential impacts at the site boundary) and funding restrictions and reductions delayed installation of wells until late 1996. Currently, the priorities and funding decisions depend somewhat on the source of funding. For example, the DOE Office of Nuclear Energy (NE) is responsible for funding the HFBR facility (and most other DOE reactors), including funding to meet environmental compliance requirements, while the DOE Office of Energy Research (ER) funds most of the experiments performed at the HFBR and the DOE Office of Environmental Management (EM) funds the environmental restoration efforts. Further, funding decisions are inherently complex at DOE's multiprogram laboratories because some activities may be funded through general plant project funding or overhead while others are funded through specific programs. In an environment of continued pressure to reduce budgets, there is significant competition for funding, and tradeoffs must be made between support functions and scientific programs. The decisions about funding the monitoring wells are typical of the complexities associated with funding decisions at multiprogram laboratories. For example, the environmental requirements at the HFBR had to compete with other NE priorities and other general plant projects for funding in the 1994 to 1996 timeframe; it was eventually funded under a special maintenance account after having been postponed several times. Now that a release has occurred, methods to fund the recovery effort need to be clearly established both in the short-term plume recovery phase (i.e., the effort to pump or contain the plume) which is primarily an NE (or ER and NE) responsibility and the long-term remediation phase (presumably there will be some level of residual tritium that is not feasible to recover), which may become an EM responsibility. To ensure effective prioritization, the following actions should be considered:

- DOE and BNL should approach the prioritization and location of groundwater monitoring wells from a sitewide hydrogeologic standpoint. The approach should provide for better integration and prioritization of sitewide and individual facility groundwater protection monitoring and restoration investigation monitoring, and should clearly identify BNL and DOE management roles, responsibilities, and authorities.

- DOE and BNL should evaluate the need for down gradient monitoring at other BNL facilities identified as containing significant tritium inventories.

- DOE and BNL should improve the funding methodologies for the sitewide groundwater monitoring program, including providing shelter from overhead or landlord funding priorities and assuring that budget reductions properly consider environmental priorities.

- DOE and BNL should clearly define the threshold at which the HFBR tritium plume monitoring and recovery will be transferred to the EM Office of Environmental Restoration organization and EM funding.

- DOE should communicate and apply lessons learned to other BNL facilities and DOE sites where funding reductions or limitations may impact timely installation of environmental monitoring and surveillance programs.